THE GENUS NEOTROMBIDIUM (ACARINA: LEEUWENHOEKIIDAE) I. DESCRIPTION OF THE OVUM AND LARVA OF NEOTROMBIDIUM BARRINGUNENSE HIRST 1928, WITH AN ACCOUNT OF THE BIOLOGY OF THE GENUS

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SUMMARY

The genus *Neotrombidium* Leonardi 1901 has been known hitherto from only the adult and nymphal forms. This paper records the experimental rearing of the larva of the Australian *Neotrombidium barringunense* Hirst 1928 from eggs laid by adults. The ovum and larva of this species are described. From this larval description it is shown that the monotypic larval genus *Monunguis* Wharton 1938, with *M. streblida* Wharton 1938 as type, found parasitic on a Streblid (Diptera) ectoparasite on a bat in a cave in Yucatan, Mexico, belongs to Leonardi's genus, which has taxonomic priority. This correlation shows that the range of *Neotrombidium* includes Central America as well as the previously recorded South America and Australia.

Further Australian records of the distribution of *N. barringunense* are given, the species being known from the eastern half of Australia. In the Adelaide region the adults and nymphs are found most commonly under the fresh bark of the bluegum, *Eucalyptus leucoxylon*. Adult females lay 30 - 50 eggs, average 40, at a time, and there appears to be only one oviposition. Adult females survive oviposition by 7 - 30 days. About three to four weeks is passed in the egg stage. Other aspects of the biology of the species are discussed.

In 1901 Leonardi erected the genus *Neotrombidium* for *N. furcigerum* from Argentina. In 1912 Berlese added a second species to the genus, *N. ophtalmicum* (sic), originally described as *Trombidium ophtalmicum* Berlese 1888 from Paraguay. Hirst added *N. barringunense* in 1928, giving as locality information, "Barringun, New South Wales, on the Queensland border, a single specimen found by the author under the bark of a living Eucalypt." In 1929 Hirst recorded the species again, noting that "this species is very abundant under the bark of gum-trees on the banks of the River Darling at Menindie, New South Wales, July 1928." In 1936 Womersley recorded this species from Long Gully, Mount Lofty Ranges, South Australia, 12 May 1934, and from Bathurst, N.S.W., 31 May 1934. In 1945 Womersley erected the family Leeuwenhoekiidae for *Leeuwenhoekia* Oudemans 1911 and related genera, separating these from the Trombiculidae Ewing 1944, and also from the old family Trombidiidae Leach 1815. G. M. Kohls and C. B. Philip, of the United States Typhus Commission, had succeeded in rearing three species of the genus *Acomatacarus* Ewing 1942 from New Guinea from larvae to nymphs, and this reared material was sent to Mr. Womersley for description. This showed that the genus *Neotrombidium*, whose larval form was unknown, had mature forms similar to those of *Leeuwenhoekia*, *Acomatacarus*, etc., and should be placed in this family.

For some years the present writer has attempted to correlate larval and adult Trombidiids (s.l.) as well as other mites, by rearing experiments. In the family Trombidiidae (s.l.) a number of genera have been so correlated. In 1939 Womersley was permitted to describe the larvae of *Chyzeria* and *Caenothrombium* which the writer had thus reared during 1938. In 1946 the writer recorded that the egg of *Microtrombidium hirsutum* Wom. 1945 hatches direct to the nymph, the larval stage being suppressed. Several other genera have been reared, these correlations at present awaiting description. From 1938 onwards the writer attempted to rear the larva of *Neotrombidium barringunense*, which species is not uncommon in the Adelaide region. Technical difficulties however prevented success, and the studies were interrupted by the war. In 1948 these experiments were resumed with *N. barringunense*, and the larva was reared from eggs laid by adults in captivity (see later).

Description of Egg. Fig. 1 A-C. Colour reddish-orange. Length 240μ, width 145μ. The eggs are in the deutovum stage when first laid, in fact in mounted gravid females the eggs show considerable development. When first laid the eggs are smooth and ovoid, but within a few days become very irregular from a number of protuberances, and it is this stage that is figured. This stage is more irregular than for most of the Trombidiidae (s.l.). Some of the protuberances can be identified as containing various parts of the larva. On the under-surface the projecting legs can be seen; protuberances I, II and III in fig. 1 C correspond to legs I, II and III.

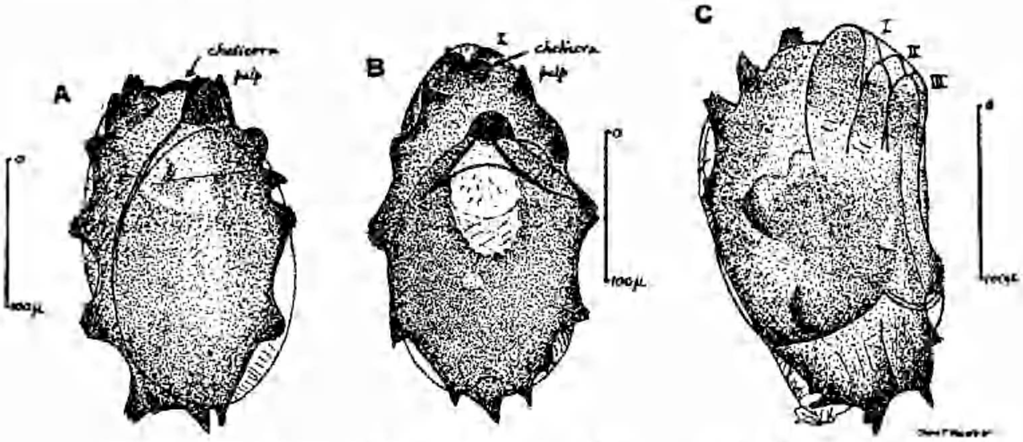

Fig. 1, A-C *Neotrombidium barringunense* Hirst, ovum. A, B: dorsal views; C: lateral view. I, II and III indicate developing legs I, II and III.

Anteriorly the protuberances for the palpi and chelicerae are identifiable (see fig. 1 A,B). Further back on the dorsum is a large nasus, which appears to correspond to the nasus of the dorsal scutum of the larva. Ranged around the lateral sides and posterior pole are several blunt or pointed protuberances, of unknown function.

Description of Larva. Fig. 2, 3 A-C. Colour orange. Body ovoid, as figured; length from tip of nasus of dorsal scutum to posterior end of abdomen 190μ, width 140μ. Dorsal scutum 92μ long by 78μ wide, roughly triangular, the apex of the triangle forwards, where the shield narrows to a blunt nasus which partly overlies the gnathosoma (capitulum). The anterolateral borders of the shield are concave, the other borders are convex except that the posterior border is considerably flattened. Scutum with a pair of sensillary setae, long, fine, very faintly ciliated, 46μ long, arising from large sensillary areolae in the posterior half of the shield; with three pairs of non-sensillary setae, the anterior (antero-median) arising on the nasus as shown, fine, pointed, ciliated, 22μ long; the antero-lateral arising very close to the edge of the antero-lateral shoulders of the shield, comparatively slender, but thicker than the antero-median, with adpressed ciliations, and slightly tapering, blunted at the tip, 22μ long; the postero-lateral setae similar to the antero-lateral, arising at the postero-lateral angle of the shield, 18μ long. The scutum is porose over its posterior half. Eyes two on each side, sessile, situated alongside the lateral borders of the shield, the anterior eye the larger. Dorsum of abdomen with about 20 setae, similar to scutal non-sensillary setae, only longer, 24-26μ long, arranged in rows of 6,4,4,2,4. Ventral surface: attached to the posteromedial angle of coxa I is a long pointed sparsely ciliated seta 35μ long; between coxae III is a pair of similar setae, 30μ long; behind coxae III are three rows of setae, long, pointed, sparsely ciliated, 40-42μ long, arranged in rows of 2, 4, 2; in addition there is a shorter pointed seta, with a few similar pointed ciliations, 16μ long on each side of the anus. Coxae I and II are contiguous on each side, with the usual stigmal opening (urstigma) between them. Coxae I and III show a recticular porose patterning in their lateral halves, not present on coxa II. Toward the anterolateral angle of coxa I arises a long pointed strongly ciliated seta 40μ long; on coxa II is a similar seta 52μ long; on coxa III similar, 42μ long. Legs of normal length, leg I 245μ long,

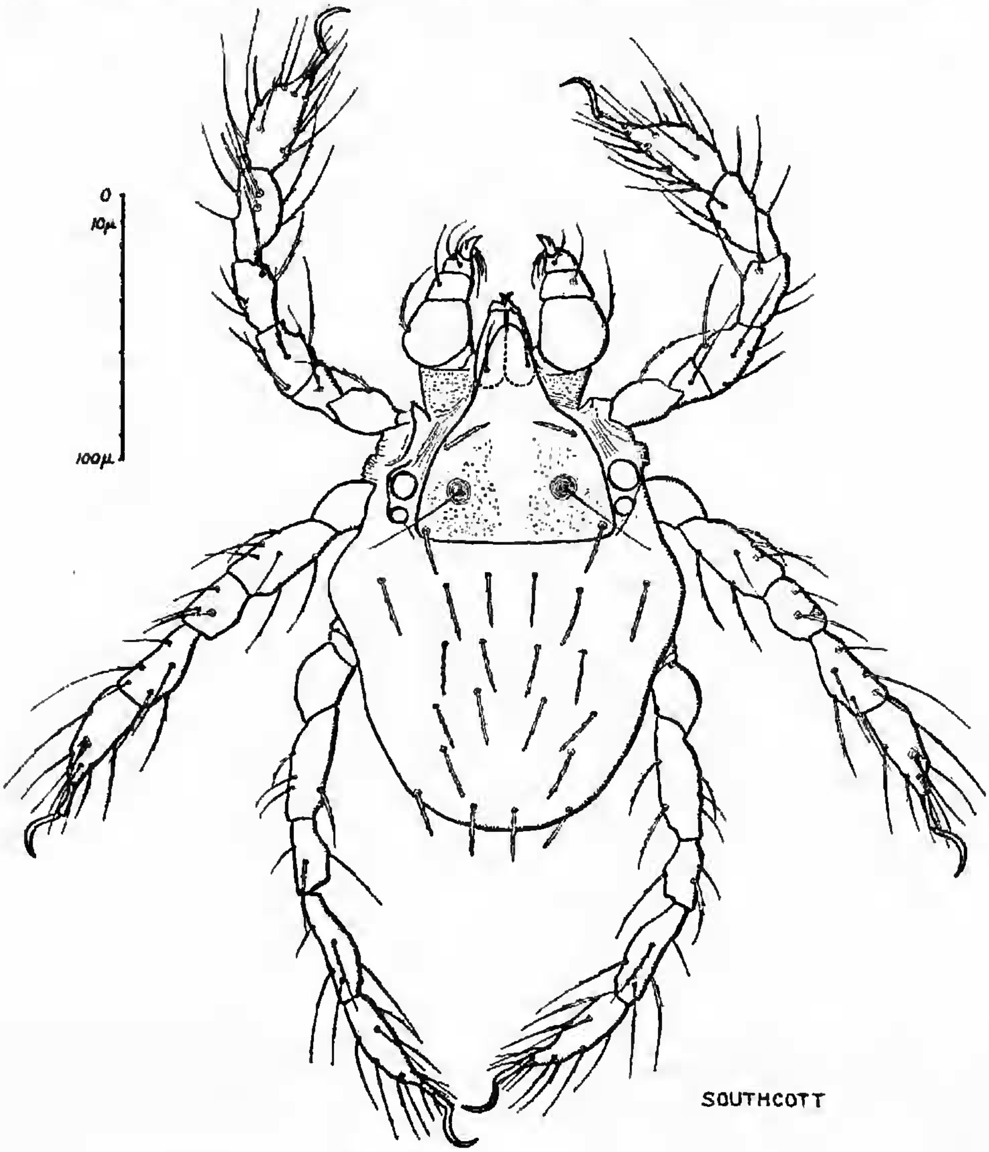

Fig. 2 *Neotrombidium barringunense* Hirst, larva. Dorsal view, entire.

II 245μ, III 265μ (all lengths include coxa and claw). Each tarsus of the legs with a single strong falciform claw. Setae and spines of legs as figured. Tarsus I and II are provided on their dorsal surface with a solenoidal spine. Tarsi without Haller's type organ. Tarsus I stout, 54μ long by 23μ high. Metatarsus I stout, sinuous, 38μ long. Gnathosoma (capitulum) compact. Basal segment of chelicera elongated, ovoid, 40μ long by 14μ wide, cheliceral digit curved, with a minute external tooth. Galeal seta short, curved, pointed, ciliated, 14μ long. No hypostomal lip present. Setae on basis capituli long, tapering, ciliated, pointed, 40μ long. Palpi as figured. Palpal femur, genu, tibia, tarsus with 1,1,3,8 setae respectively. Claw of palpal tibia strongly bifurcate, as shown.

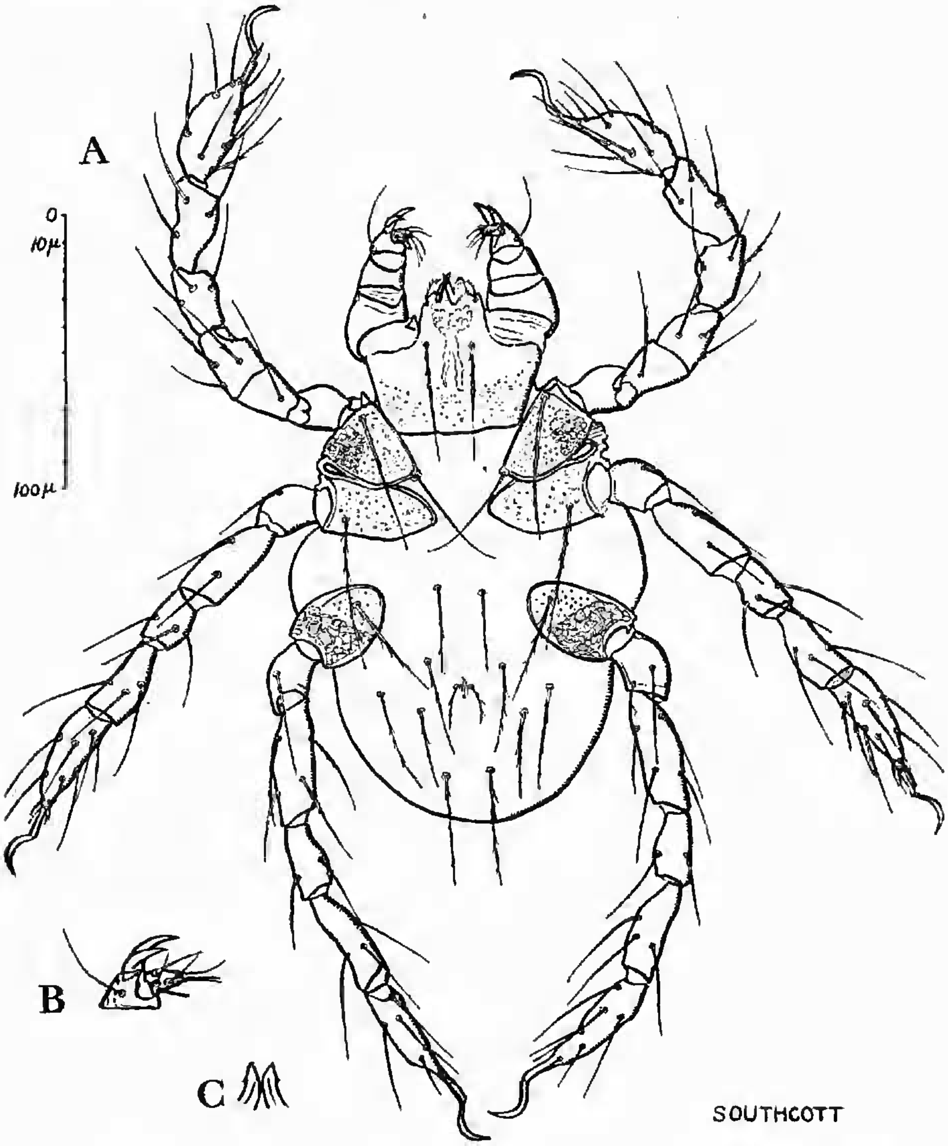

Fig. 3, A-C *Neotrombidium barringunense* Hirst, larva. A: ventral view, entire; B: tarsus and tibia of palp, ventral; C: tips of cheliceral digits.

GEOGRAPHICAL DISTRIBUTION OF N. BARRINGUNENSE

The following additional localities are recorded: —Queensland: Dead Man's Gully, north of Cairns, 29 November 1943, 4 specimens under bark of *Eucalyptus* sp.; 31 December 1943, 1 specimen from similar habitat; 2 January 1944, 1 specimen (no further field notes). Irvinebank, 28 September 1944, 1 specimen from under bark *Eucalyptus* sp. South Australia: Adelaide region (see next section). (All specimens collected by writer.)

BIOLOGY IN THE ADELAIDE REGION

Around Adelaide, South Australia (Glen Osmond and Heywood Park), adults or nymphs have been taken by the writer from May onwards to February, over 1938-1941 and 1948-1951. An occasional specimen has been found in soil, or under the bark of *Eucalyptus camaldulensis*, but practically all the specimens from the Adelaide region have been taken under the bark of the trunks of *Eucalyptus leucoxylon*, in the splits between fresh layers of damp bark, and I have no doubt that in the Adelaide region at least there is a very strong association between this mite and *Eucalyptus leucoxylon*. By August or September the adult females are seen to be, in mounted specimens, gravid with eggs which show a good deal of development. About 30-50 (average 40) eggs can be counted filling the body in these mounts. Oviposition has occurred on six occasions with captive females. Only one oviposition has been observed with each female, up to 40 or perhaps more eggs being laid. After oviposition mounted females contain no eggs. On three occasions I have succeeded in rearing larvae from eggs laid in captivity.

Details of Successful Rearings

(1) Experiment ACB 398. Two adults were taken from under bark of *Eucalyptus leucoxylon* at Heywood Park, South Australia 26 September 1948, and these were placed in a glass tube with some bark from the tree. On 14 November 1948 the mites were healthy and no eggs were present in the tube. On 7 December the tube was re-examined. One adult mite was rather shrunken. Nine active larvae were running around the tube. No attempt at feeding these was made, and by 28 December all the larvae were dead. The adult was shrunken, but otherwise appeared healthy.

It appears from this experiment that the period from oviposition to hatching of the larvae is less than 23 days. The eggs were not seen, except as egg skins present along with the larvae.

(2) Experiment ACB 399. Two specimens of *N. barringunense*, one adult, one nymphal, were captured in the same situation as ACB 398 on 26 September 1948, and confined in a damp atmosphere in a glass tube. Water was added periodically as droplets to maintain humidity. Eggs, of the same colour as the adult, were laid between 10-17 October 1948, a total of 19 being laid. On 17 October the eggs were recorded as "almost smooth," having been laid in a little pit formed between the cork and the glass wall of the tube, or else scattered around over the surface of the cork or the glass. By 19 October the eggs were irregular, with the typical deutovum outline. The eggs hatched out initially on 12 November 1948, and continued to hatch out on subsequent days.

Hence the period between oviposition and hatching ranged from $29 \cdot 5 \pm 3 \cdot 5$ days upwards.

(3) Experiment ACB 400. Eight specimens of *N. barringunense* were captured in the same situation as the preceding on 26 September 1948. These were placed in a damp tube with some bark from the tree. The tube was kept humid by the periodical addition of droplets of water. Some of the specimens were

damaged in capture, and by 14 November it was recorded that five adults were alive but some were a little shrunken and that ten living healthy larvae were running around in the tube. The tube was then allowed to dry out, but one adult survived until 2 February 1949 when it was extremely shrunken, its abdomen scaphoid across the dorsum.

Hence the period from oviposition to hatching was less than 23 days.

From these and other experiments one may conclude that in the Adelaide region eggs are laid in November or early December, and that three to four weeks is passed in the egg stage. Some of the larvae were placed on human skin to see if any attempt at parasitization would be made, but none was observed. I recorded with one batch of larvae that they appeared to be positively, though weakly, phototropic. Adults of this species can withstand extreme desiccation for weeks, and it is sometimes a cause for wonder how they can survive when so extremely shrunken. Usually Trombidiids (s.l.) do not withstand desiccation well. The habitat of *N. barringunense*—under damp bark of *Eucalyptus*—is a very unusual one, the majority of Trombidiids (s.l.) dwelling in damp soil, and presumably the power of this species to withstand dry conditions is necessary for survival with their choice of habitat.

DISCUSSION ON THE AFFINITIES OF THE LARVA

Wharton (1938) described as new *Monunguis streblida*, a remarkable larval Trombidiid mite parasitic on the batflies *Pterellipsis araneae* Coquillett and *Trichobius dugesii* Townsend (Diptera:Streblidae) from the Cinquo de Mayas Cave, Tekax, Yucatan, Mexico. This larval mite has a strong resemblance to the larva of *Neotrombidium barringunense*. It has one large claw to each tarsus, and the dorsal scutum is similar, except for a bizarre appearance or structure between the scutal sensilla, sketched by Wharton, which has no comparable structure in *N. barringunense*, and may be an artefact. In the two forms the dorsal scutum shows a strong resemblance in shape and chaetotaxy. Wharton states that the coxa I and coxa II of *Monunguis* are separated, but unfortunately he does not figure this feature. In this latter feature Wharton compares *Monunguis* with the European larval mite *Rohaultia biungulum* Oudemans 1911. Oudemans (1912) says of this latter species "coxae I und II getrennt," and comments on its "Hydrachnid," especially Limnocharid, affinities. Vitzthum (1913) appears to have been responsible for considering *Rohaultia biungulum* as the larva of the previously described adult species *Johnstoniana errans* (Johnston 1852), although I can find no grounds stated by him anywhere for this correlation. It would appear from Willmann (1947) that the only grounds used by Vitzthum were that the adults and larvae were associated in the field. Similar considerations have led other students of the Acarina into error. Thus Womersley (1934) accepted the species now known as *Sphaerotarsus womersleyi* Southcott 1946 as the nymph of *Caeculisoma ripicola* Womersley 1934 on what appeared to be a strong association in the field. Oudemans (1912) classified the larvae now grouped under *Trombicula* and related genera under the genus *Microtrombidium*, quite erroneously.

Unfortunately Wharton does not, in his very brief description, comment on the presence or otherwise of the "urstigma," but as he places the larval *Monunguis* in the Trombidiidae as against the Erythraeidae one may assume that it is present. The only serious point of difference in the descriptions of *Monunguis* and larval *Neotrombidium* lies in the contiguity or otherwise of coxae I and II, in which possibly Wharton was mistaken. There are so many resemblances between these larvae that there appears little doubt that *Monunguis* and *Neotrombidium* are congeneric, and as the latter genus has priority it must take precedence over *Monunguis*. *Neotrombidium streblidum* (Wharton 1938) is undoubtedly specifically distinct from the only other known larval species of this genus, *Neotrombidium barringunense* Hirst 1928. These species differ in the structure of the non-sensillary setae of the dorsal scutum, the number and arrangement of the dorsal setae of the abdomen, and in various other characters.

DISCUSSION ON THE BIOLOGY OF *NEOTROMBIDIUM*

Previously the genus *Neotrombidium* has been known as the adult forms from Australia and South America. The correlation recorded in this paper extends the known range to Central America.

Wharton states that the larvae (*N. streblidum*) "were found to be parasitic on the streblid flies which infest the bats" in the Yucatan caves. The species of bats concerned are not mentioned by Wharton, but from other articles in the account of the fauna of the Yucatan caves (Pearse 1938 a and b, Pearse and Kellogg 1938) it appears these flies were obtained from two specimens (male and female) of the fruit-eating bat *Artibeus jamaicensis yucatanicus* (Allen) on 29 July 1936.

It is reasonable to assume that the larvae of the Australian *N. barringunense* have the same type of host as does the American species, and we may expect to find the larvae in Australia parasitic on the Streblid flies parasitic on Australian bats. The genus *Artibeus* is not represented in Australia (Troughton 1943), hence any further suggestions as to what bats may be concerned must remain conjectural. In fact, only a few fruit bats have been recorded from South Australia, and these appear to have been stragglers (Wood Jones 1925). Of the dipterous family Streblidae no species appears to have been described from Australia, and they certainly appear to be far from common. Tillyard (1926) states that one undescribed Streblid has "been taken by Dr. Illingworth in north Queensland." A few other dipterous bat parasites (Nycteribiidae) appear to occur in Australia, and one species has been described (Tillyard 1926, Rainbow 1904, Speiser 1905).

The larvae of the Trombiculidae and Leeuwenhoekiidae are parasitic on vertebrates, only a few exceptions to this rule having been recorded. On one occasion the writer captured a larva of *Tragardhula pentagona* Womersley 1952 running freely over the black fur on the thorax of a female *Troides priamus* (butterfly) in rain forest eight miles east of Wondecla, north Queensland, on 20 October 1943 (*not* August, as recorded by Womersley). Audy (reported in Womersley 1952 and *in lit.*) has found the larval *Trombicula rara* Walch 1923 parasitic on the pill-millipede *Sphaeropaeus globus-magicus* Jeekel 1951, as well as *Trombicula frittsi* Wharton 1945 parasitic on the scorpion *Heterometrus longimanus* in Malaya. André (1943) recorded *Leeuwenhoekia paradoxa* André 1943 parasitic on the scorpion *Buthus gibbosus* Brulé on the island of Gavdos (south of Crete). These findings are exceptional, but demonstrate that such larvae may utilize an arthropod host.

It is difficult to imagine how in the open forest situations in which *Neotrombidium barringunense* is found in Australia the numbers of adults of this species are maintained if only the apparently rare Streblid flies may be used as hosts by the larvae. In the cases observed in captivity the adult female lays a number of eggs, either in a loose cluster, or scattered singly, the batches observed in the tubes numbering between 20 - 40 eggs. Only one oviposition has been observed in each female. Gravid females contain 30 - 50 eggs (average 40), which frequently show considerable differentiation of the contained embryo, although the egg is initially smooth on being laid. After oviposition the females are devoid of eggs in mounted specimens, which is confirmatory of the suggestion that there is only one oviposition. Oviposition is not immediately lethal to the female; in *Neotrombidium barringunense* I have observed the female to survive 7 - 30 days after oviposition, which usually leaves it very shrunken. (With other Trombidiid mites I have on occasions observed the female to survive months after oviposition, under suitable conditions, which are easier to maintain than those required for *Neotrombidium*). The slight disparity between the numbers of eggs observed after oviposition and the number within the ovaries of the gravid female may be due to experimental errors—*e.g.*, the mites tend to lay their eggs in any minute crack in the bark provided, or in the corks sealing the tubes, etc.

Presumably the larva of *Neotrombidium barringunense* hatches out under the bark of *Eucalyptus leucoxylon* or some similar habitat, runs up the tree to find a suitable host, either free in the tree or parasitic on a bat, and after feeding pupates, presumably after falling to the forest floor, and finally reaches its Eucalypt habitat as a nymph, and remains there to complete the remainder of its life cycle. It is worthy of investigation whether the flies of the related Dipterous family Hippoboscidae, which occur on birds in small numbers, might serve as a host for the larval mites.

Although such a life history as outlined may appear fantastic, it is not more so than for example Fabre has recorded in his classic researches on the life of the anthrax fly.

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